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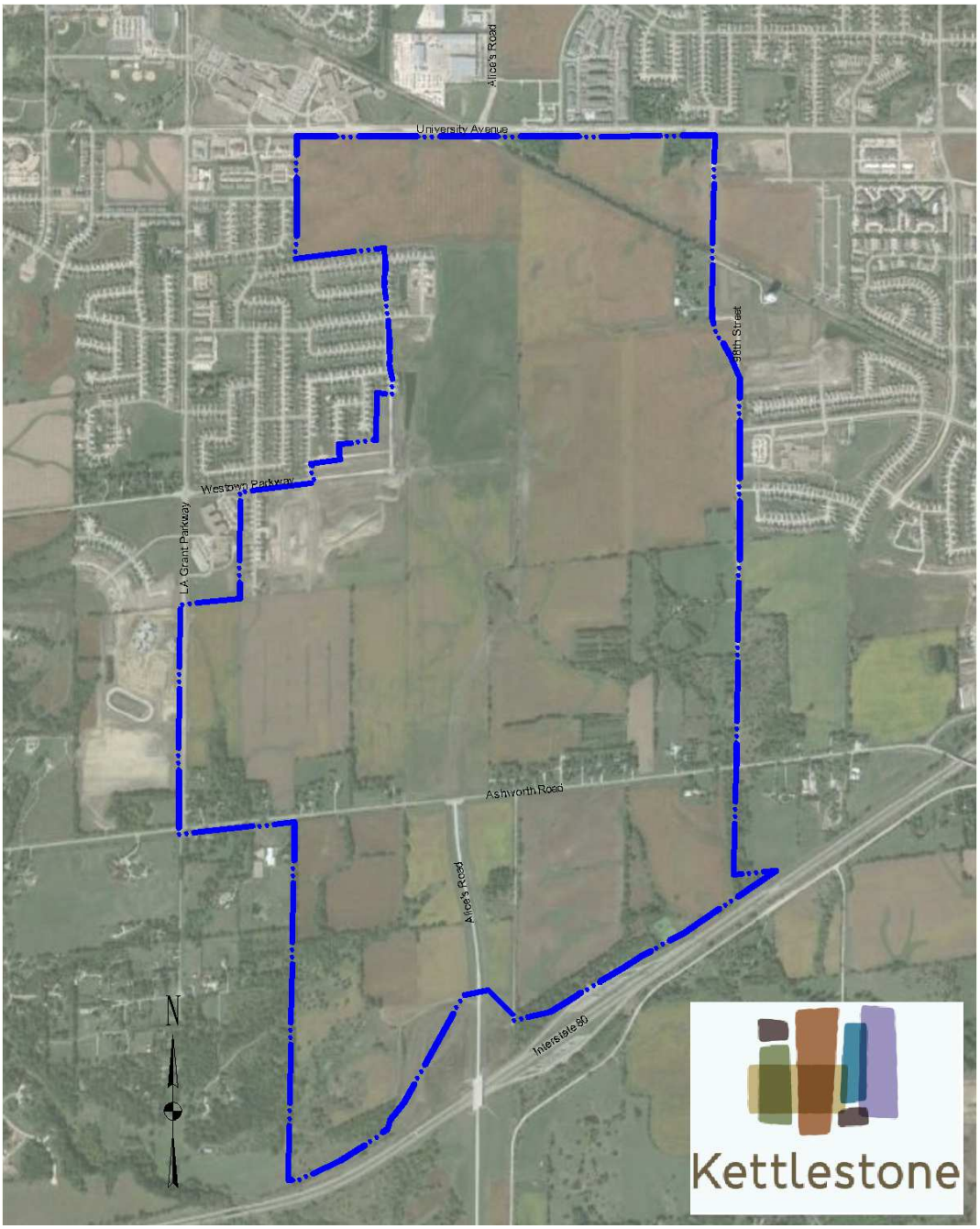
Kettlestone Development
Waukee, Iowa
Site Geotechnical Considerations



SITE GEOLOGY

Overburden Soils

Kettlestone Development is named after its glacial knob and kettle or swell and swale terrain. The undulating and gently rolling landform with wide ridgetops and long side slopes was formed by the last major glaciation in Iowa, the **Wisconsinan glacier**, which terminated in this area just one mile or less south of Interstate 80. Steeper sloping terrain exists closer to Fox Creek and Sugar Creek located generally southeast and southwest of Kettlestone.

Sandy lean clay (CL) **topsoil** less than 2 feet thick has developed on the knolls. The upper 6 to 8 inch zone is organic enriched. **Local alluvium** or topsoil sediment that has washed down and been redeposited in the kettles is typically a 2 to 4 foot thick layer of lean to fat clay (CL-CH).

Because of the nature of glacial depositions, occasional pockets of organic **peat** can be present. Previous construction at the development, such as farmsteads, may have localized deposits of uncontrolled **existing fill** which may need mitigation in the future.

The surficial soils are underlain by **Wisconsinan glacial till** composed predominantly of sandy lean clay (CL) with traces of pebbles and gravel. Typical of glacial formations, sand layers or pockets ranging from seams a few inches thick to layers of glacial outwash several feet thick are randomly interbedded in the otherwise cohesive soil. Cobbles and boulders generally 3 feet or less in size are erratically encountered. The upper portion of the glacial till is generally medium stiff to stiff with the soil gradually becoming stiffer with depth.

Wind deposited lean clay (CL) **loess** soils that mantled the landscape prior to the Wisconsinan glaciation underlie the glacial till about 30 to 50 feet below ground surface. These siltier cohesive soils are typically medium stiff to stiff.

Two or more previous glacial ice masses advanced through this area of Iowa prior to the loess deposition. The sandy lean clay (CL) with traces of pebbles and gravel deposited by these glaciers is referred to as **Pre-Illinoian glacial till**. The surface of this formation in this area may be about 40 to 60 feet below ground surface. One or more several foot thick layers of weathered glacial fat clay (CH), referred to as **paleosol**, identify the breaks between the glacial advances.

Bedrock

Pennsylvanian sedimentary bedrock is the upper bedrock formation underlying the overburden soils. **Clay shale** is the predominant bedrock material with lesser extensive sandstone, siltstone, limestone and coal layers. Depth to the hard to very hard bedrock may vary from 75 feet to more than 100 feet below ground surface.

Some areas in Waukee have been mined for coal in the late 1800's and early 1900's, usually at depths of 200 feet or more below ground surface. Records available through the Iowa Department of Natural Resources indicate that there are **no known abandoned coal mines** under Kettlestone.

Groundwater

The gently rolling terrain and predominantly cohesive soils present throughout much of Kettlestone causes relatively shallow

groundwater levels to be present during periods of normal to above normal precipitation periods. Seasonal high groundwater levels may be greater than 5 feet below ground level on the ridgetops but may be temporarily near the ground surface in the depressions.

Agricultural field drain tile may be present throughout the area, especially on the sideslopes and bottomlands, which have lowered groundwater levels down to about 3 to 4 feet below ground surface. Provisions to continue these drain lines may be necessary where encountered during construction.

Construction dewatering in excavations can normally be accomplished with sump pumps if moisture seepage occurs from the cohesive glacial till. Sand lenses or pockets may drain for a period of time. However, excavations into several foot thick water bearing sand layers may warrant temporary wells to lower groundwater levels to about 2 feet or deeper below the bottom of the excavation to avoid a quick condition and loss of subgrade support.

Groundwater levels will change, possibly lowered, as Kettlestone is developed with site grading, surface drainage, and storm sewer installation. However, irrigation practices can recharge groundwater levels. Subsurface drainage is necessary around and below basement structures but is usually not necessary for slab-on-grade structures if the surface drainage is positively directed away from the buildings.

While the site is susceptible to shallow groundwater levels, the predominantly cohesive overburden soils are not reliable sources of water for wells, such as for irrigation.

DESIGN AND CONSTRUCTION

Site Grading

Much of the Kettlestone development area is agriculture land and the organic rich zone is normally about 6 to 8 inches deep where fields have only been chisel plowed. An **average stripping depth of 6 inches** is common, although deeper stripping may be necessary in low areas and treed locations.

The glacial till soils are commonly graded with scrapers and compacted with **sheepsfoot rollers**. Utility trenches are frequently compacted with vibratory plate attachments on backhoe excavators or self-propelled pad foot rollers.

The cohesive soils under normal to above normal precipitation periods are commonly near or above the recommended moisture content range necessary to achieve a high level of compaction. **Discing and aeration** is the most common method to lower moisture contents when climatic conditions permit. Moisture conditioning the soil with Class C fly ash or quicklime is used under more extreme moisture conditions or time restrictions. Prolonged dry conditions may necessitate controlled water incorporation to achieve the proper moisture levels.

Chemical stabilization with Class C fly ash or quicklime can be used to increase soft soil subgrade strength or stabilize expansive soils. Rotary pulvamixers work well to incorporate the chemicals.

Excavations

The glacial till can normally be removed with **routine trenchers, backhoe excavators, and end loaders**. Occasional

large cobbles and boulders should be expected.

Shallow excavations in the cohesive glacial till above the groundwater may remain stable for short periods of time, such as for shallow utilities or trench footings. However, moisture seepage or sand deposits may cave into excavations. Dewatering considerations have been discussed in the *Groundwater* section.

By OSHA standards, the natural cohesive glacial till would typically be classified as Type B or C and sand would be **Type C** in excavations less than 20 feet deep. However, site specific conditions must be evaluated by the contractor's competent person.

Corrosivity

The cohesive Wisconsinan glacial till and local alluvium are considered potentially corrosive to unprotected underground metal piping. **Type 1 Portland cement** concrete is commonly used in the area for concrete elements in contact with the on-site soils. Laboratory tests of soil resistivity, pH, and total/soluble sulfate content can be conducted to verify corrosive properties.

Expansive Soils

The natural sandy lean clay (CL) Wisconsinan glacial till soils normally exhibit Liquid Limits of less than 45 and Plasticity Indexes less than 23. These low to moderately plastic soils are not considered expansive. However, the near surface lean to **fat clay (CL-CH) local alluvium** and some portions of the topsoil are moderately to highly plastic and **can expand** as water is absorbed into the soil. This can cause lightly loaded floors and foundations to heave, or settle if the soil dries substantially. Trees should be planted a safe distance away from buildings to reduce settlement from desiccation during droughts.

Footings having sustained bearing pressures greater than 500 pounds per square foot, preferably more, can normally resist the potential swell pressures. Where these soils are present within 2 to 3 feet below a floor slab, typically the soils are over-excavated to accommodate placement of low plasticity glacial till fill or granular fill.

Pavements are subject to frost heave and are not as sensitive to soil swell movements. However, having one foot or more of low plasticity soil under the pavement is desirable.

Slab-On-Grade Floors

Compacted low plasticity cohesive soil under slab-on-grade floors usually results in a **modulus of subgrade reaction of 100 to 150** pounds per square inch/inch, depending upon the thickness of the compacted zone. The granular floor base material should be compactable, trimable and stable under construction traffic. Crushed aggregate is preferable for this purpose rather than alluvial sand. Depending upon floor coverings and expected water levels, a vapor barrier/retarder is used with the placement location dependent upon design and construction variables.

Foundation Options

Many one and two story commercial buildings can be supported with **trench or spread foundations**. The Wisconsinan glacial till allows the use of allowable foundation pressures typically ranging between 1500 to 3000 pounds per square foot (psf). It is not uncommon, however, to

encounter soft to medium stiff natural soils that warrant partial depth removal and replacement with soil or granular compacted fill sections 2 to 4+ feet deep and beyond the footing to achieve reliable support and settlements of less than one inch.

Heavier buildings with column loads in excess of 200 kips may benefit from support with ground improvement systems, such as **rammed aggregate piers**, which allows the use of design foundation pressures of 4,000 psf or more. Augered cast in place piles and drilled piers deriving skin friction and end bearing capacity in the deeper Pre-Illinoian glacial till are used for structures with column loads over 500 kips.

Pavements

Both rigid (Portland cement concrete - PCC) and flexible (hot mix asphalt – HMA) are suitable for paving purposes. Pavements are commonly placed directly on compacted cohesive glacial till soils employing a design California Bearing Ratio **(CBR) of 3 to 5**. Placement of a compacted rock base under the pavement with subsurface drain lines will improve pavement longevity and performance. Excess water from irrigation in landscaped areas adjacent to pavements can deteriorate the subgrade and bleed out of down gradient joints and cracks. Strategically placed subsurface drain lines can intercept and divert this water safely away.

Frost Heave

Key elements contributing to frost heave including freezing temperatures, available water, and fine grained frost susceptible soils are present at most sites in Iowa. **Frost heave** problems are generally **common** and most noticeable in pavements or sidewalks adjacent to non-frost susceptible elements such as manholes, light poles, and exterior doors or frost protected stoops. Sometimes it is not readily apparent why frost heave problems occur at one location and not at another seemingly similar location.

While it is appropriate to implement measures to reduce frost heave such as insulation, replacing frost susceptible soils with less frost susceptible soils, void forms, sealing cracks/joints to reduce surface water infiltration, or drainage improvements (surface and subsurface), these measures may simply move the frost heave problem to a different location where preventative measures have not been implemented. Having a smooth transition between heaved and non-heaved areas is desirable, but may be challenging or costly to accomplish.

Seismic Classification

The soil/bedrock profile in this area would generally be classified as **Site Class D** per the 2012 International Building Code and 2010 ASCE-7 Standard.

The depths and thicknesses of the individual soil strata and underlying bedrock will vary between individual sites over this large development. Where site specific seismic classification is critical to the design and cost of an individual project, seismic site testing could be conducted to determine if the site can be upgraded to Site Class C.